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DESCRIPTION

COMMUNICATION TERMINAL DEVICE AND COMMUNICATION RELAY
METHOD

Technical Field

[0001] The present invention relates to a communication terminal apparatus and communication relay method in a multihop system adopting an OFDM (Orthogonal Frequency Division Multiplex) scheme.

Background Art

[0002] In a mobile communication system as typified by a mobile telephone or the like, with the development of multimedia information, large volume data such as still image and moving image, as well as speech data, has been processed. In the future, since it is expected that the data volume will further increase, it is actively studied to realize high transmission rate by making frequency band of a radio signal higher.

[0003] However, since a radio signal of high frequency is largely attenuated depending on transmission distance, the radius of a cell covered by a base station becomes small, and therefore it is necessary to install more base stations. In a high population density area, sufficient cost effectiveness can be obtained if more base stations are installed, and therefore the problem cannot be exposed.

However, in a low population density area, for example, it is impractical to install base stations every few hundred meters. Therefore, in a low population density area, it is desired to enable communication between base

5 stations and communication terminals without increasing the number of base stations.

[0004] As a means for solving this problem, there is a technology called a multihop system (or multihop network) (for example, refer to Patent Document 1.) In this

10 multihop system, each communication terminal has a communication relay function and relays communication between another communication terminal and a base station. Therefore, a communication terminal that is located outside the communication area (outside a cell) and cannot

15 directly communicate with the base station (hereinafter referred to as a "relay requesting station") requests another communication terminal that can directly communicate with the base station to relay communication. Then, the communication terminal requested to relay

20 communication (hereinafter referred to as a "relay station") establishes a link to the base station, and relays communication between the communication terminal outside the area and the base station. By this means, the communication terminal outside the area can

25 communicate with the base station.

Patent Document 1:    Japanese Patent Application

Laid-Open No.HEI11-289349

Disclosure of Invention

Problems to be Solved by the Invention

5    [0005]  However, in the conventional multihop system, even if the subject station (relay station) does not perform communication, a circuit of the subject station is used for communication of another station outside the area (relay requesting station), and therefore, there

10   is a problem that power consumption of the subject station increases.    In particular, a communication terminal located at a cell edge (area near the boundary with a neighboring cell) has a high possibility of performing a relay for the communication terminal outside the area,

15   and therefore power consumption increases prominently. [0006]  It is therefore an object of the present invention to provide a communication terminal apparatus, in a multihop system, capable of relaying communication of another station and suppressing increase in power

20   consumption of the communication terminal apparatus, and provide a communication relay method used in the communication terminal apparatus.

Means for Solving the Problem

25   [0007]  A communication terminal apparatus of the present invention that relays communication between a base station and another communication terminal in a

communication system of an OFDM scheme, adopts a configuration having: a storage section that stores communication data between the base station and another communication terminal; and a transmission section that

5   frequency division multiplexes the stored communication data with data of the communication terminal apparatus and transmits the frequency division multiplexed data at a timing for transmitting the data of the communication terminal apparatus.

10  [0008]  A communication system of the present invention is a communication system of an OFDM scheme having a base station and a plurality of communication terminals, wherein, when a first communication terminal is requested to relay communication with the base station from a second

15  communication terminal, the first communication terminal temporarily stores relay data and frequency division multiplexes the relay data with data of the first communication terminal, transmits the frequency division multiplexed data at a timing for transmitting the data

20  of the first communication terminal, and reports the relay to the second communication terminal, and, when the second communication terminal receives the report of the relay from the first communication terminal, the second communication terminal reports the relay to a user of

25  the second communication terminal.


Advantageous Effect of the Invention

[0009] According to the present invention, in the multihop system, it is possible to relay communication between a communication terminal located outside the area and a base station, and suppress increase in power consumption of the communication terminal.

Brief Description of Drawings

[0010]

FIG.1 illustrates a case in which a mobile station within a cell relays uplink communication between a mobile station located outside the cell and a base station;

FIG.2A shows timings of uplink communication/downlink communication in a TDD system, FIG.2B is a view showing a transmission signal of a mobile station outside the area, and FIG.2C is a view showing a transmission signal of a relay station;

FIG.3 shows an example of a usage state of transmission subcarriers of a relay station;

FIG.4 shows an example of a relationship between transmission subcarriers of a mobile station outside the area and available subcarriers of a relay station;

FIG.5 shows a relationship between the number of transmission subcarriers and power consumption;

FIG.6 illustrates a case in which a mobile station within a cell relays downlink communication between a mobile station outside the area and a base station;

FIG.7A shows timings of uplink

communication/downlink communications in a TDD system,

FIG.7B shows a transmission signal of a base station,

and FIG.7C shows a transmission signal of a relay station;

FIG.8 shows an example of a usage state of

5  transmission subcarriers for a relay station;

FIG.9 is a block diagram showing a main configuration

of a mobile station apparatus according to Embodiment

1;

FIG.10 is a block diagram showing a main

10  configuration of a base station apparatus according to

Embodiment 1;

FIG.11 illustrates a flow in a case in which a relay

station relays data of a relay requesting station;

FIG.12 shows an example of a usage state of

15  transmission subcarriers for a relay station;

FIG.13 is a block diagram showing a main

configuration of a mobile station apparatus according

to Embodiment 2;

FIG.14 is a view summarizing the usage methods of

20  each frequency band in a communication system according

to Embodiment 2; and

FIG.15 is a block diagram showing variations of a

mobile station apparatus according to Embodiment 2.

25  Best Mode for Carrying Out the Invention

[0011]  Embodiments of the present invention will be

described below in detail with reference to the

accompanying drawings.    As an example of a communication
terminal apparatus, a case will be explained where a mobile
station apparatus such as a mobile telephone is used.

[0012]    (Embodiment 1)

5          One aspect of the present invention is that, in the
multihop system, even when a mobile station is requested
to perform a relay from another mobile station, the mobile
station does not always perform the relay, and the cases
of performing a relay are limited.

10    [0013]   Specifically, the mobile station according to
Embodiment 1 of the present invention is located in a
location where direct communication with a base station
is possible in the multipop system adopting an OFDM-TDD
(Orthogonal Frequency Division Multiplex – Time Division

15   Duplex) system.    When a mobile station according to this
embodiment is requested to relay communication with the
above-described base station from another mobile station
located outside the area, the mobile station performs
a relay in the following limited cases.    In addition, for

20   easy understanding, uplink communication between a mobile
station outside the area and a base station is referred
to as "uplink relay", downlink communication between a
mobile station outside the area and the base station is
referred to as "downlink relay", and uplink relay and

25   downlink relay will be explained separately.

[0014]    FIG.1 illustrates a case in which mobile station
(relay   station)   MS1   within   a   cell   relays   uplink

communication between mobile station (relay requesting station) MS2 located outside cell A1 and base station BS1, that is, a case of uplink relay.

[0015] In uplink, the cases in which mobile station MS1 performs relay are limited as follows. That is, at the timing when mobile station MS1 transmits data to base station BS1, mobile station MS1 relays transmission data from mobile station MS2 to base station BS1. To be more specific, mobile station MS1 transmits transmission data S2 transmitted from mobile station MS2 to base station BS1 together with transmission data S1 of mobile station MS1.

[0016] FIG.2A to FIG.2C illustrate a timing when mobile station MS1 relays data of mobile station MS2.

[0017] FIG.2A shows uplink communication/downlink communication timings between base station BS1 and mobile station MS1, that is, uplink communication/downlink communication timings in a TDD system. In this figure, downward arrows indicate downlink communication, and upward arrows indicate uplink communication. Furthermore, FIG.2B shows a transmission signal of mobile station MS2 outside the area (received signal of relay station MS1), and FIG.2C shows a transmission signal of relay station MS1.

[0018] As shown in FIG.2B, mobile station MS2 transmits data S2 for base station BS1 to mobile station MS1 at downlink communication timing t1 in a cellular system

(TDD system) of base station BS1.  Here, although a case is described as an example in which mobile station MS2 is synchronized with a TDD system, mobile station MS2 does not necessarily have to be synchronized.

5    [0019]    Mobile station MS1 receives data S2 and temporarily stores data S2 in a buffer.  Then, as shown in FIG.2C, after waiting until timing t4 of transmitting data S1 of mobile station MS1 comes, and at timing t4, mobile station MS1 multiplexes data S2 stored in the buffer

10   with data S1 of mobile station MS1 and transmits the multiplexed data to base station BS1.  When a waiting time of the data relay exceeds a predetermined time, mobile station MS1 discards this relay data and does not perform relay.

15   [0020]    Then, mobile station MS1 confirms whether or not there is an unused subcarrier in OFDM frequencies, that is, a subcarrier to which transmission data for base station BS1 of mobile station MS1 or a control channel signal is not mapped among available subcarriers when

20   mobile station MS1 performs transmission (available subcarrier).  Then, if there is an available subcarrier, mobile station MS1 determines whether the available subcarrier has enough capacity for a data relay (whether the capacity of available subcarrier is larger than the

25   size of relay data).  If there is not enough capacity for a data relay, mobile station MS1 does not perform a relay.

     [0021]    FIG.3 shows an example of a usage state of

transmission subcarriers for relay station MS1.

[0022]    In this example, subcarriers having center frequencies f1 to f12 are subcarriers to which transmission data of mobile station MS1 is mapped (subcarreirs for MS1), and a subcarrier of center frequency f17 is a subcarrier to which a control channel is mapped.    Therefore, subcarriers having center frequencies f13 to f16 are the above-described available subcarriers.

[0023]    Then, since there are available subcarriers, mobile station MS1 confirms the capacity of these available subcarriers and relays communication between mobile station MS2 and base station BS1.    To be more specific, mobile station MS1 maps data which is requested to be transmitted from mobile station MS2 to base station BS1, to the above-described available subcarriers.  Here, when the frequencies of transmission subcarriers for mobile station MS2 are covered by (included in) the frequencies of available subcarriers for mobile station MS1, mobile station MS1 maps data of mobile station MS2 to subcarriers with the frequency as it is.

[0024]    Then, after mobile station MS1 multiplexes subcarriers to which data of mobile station MS2 is mapped with subcarriers to which data of mobile station MS1 is mapped and obtains a multicarrier signal, mobile station MS1 transmits this multicarrier signal to base station BS1.

[0025]   In addition, when the frequencies of transmission subcarriers for mobile station MS2 are not covered by the frequencies of available subcarriers for mobile station MS1, mobile station MS1 changes frequency as described below.   FIG.4 shows an example of a relationship between transmission subcarriers for mobile station (relay requesting station) MS2 outside the area and available subcarriers for relay station MS1, that is, a case in which both subcarriers have the above relationship.      Here,   FIG.4A   shows   transmission subcarriers for mobile station (relay requesting station) MS2, and FIG.4B shows available subcarriers for relay station MS1.

[0026]   In an example of this figure, while the range of center frequencies of transmission subcarriers for mobile station MS2 outside the area is between f13 and f16, the range of center frequencies of available subcarriers for relay station MS1 is between f1 and f6.   In this way, the frequencies of transmission subcarriers for a mobile station which requests a relay are not always covered (included) by the frequencies of available subcarriers for the relay station.   In this case, relay station MS1 maintains (fixes) the frequencies of transmission subcarriers for relay station MS1, and shifts the frequencies of transmission subcarriers for relay data so that the frequencies of transmission subcarriers for the relay data are included within the frequency range

of available subcarriers.    In the example of FIG.4, the
range of center frequencies of relay data subcarriers
change from f13 and f16 to f1 and f6.    By this means, mobile
station MS1 can smoothly relay data.    Furthermore, since
5    relay station MS1 does not change the frequencies of
transmission subcarriers for relay station MS1, for
example, even in a communication system such as frequency
scheduling in which subcarriers are assigned to use in
advance to each mobile station, the frequency scheduling
10    functions effectively.

[0027]    Next, the effects of adopting the above
communication relay method will be described.    FIG.5
shows a relationship between the number of transmission
subcarriers for a mobile station and power consumption.

15    [0028]    As shown in this figure, if there is at least one
transmission         subcarrier         (actually         transmitted
subcarrier),    power consumption of the mobile station
substantially increases compared to the case where there
is no transmission subcarrier.    However, when the number
20    of transmission subcarriers further increases, increase
in power consumption slows down, and, even if the number
of transmission subcarriers increases, power consumption
does not change substantially compared to the case where
the number of transmission subcarriers is one.

25    [0029]    Consequently, when mobile station MS1 performs
transmission--that is, when the number of transmission
subcarriers is 1 or more--mobile station (relay station)

MS1 according to this embodiment maps data of another station (such as mobile station MS2) to available subcarriers and transmits the subcarriers. If such transmission is performed, it can be seen from FIG.5 that

5    power consumption of mobile station MS1 increases little. Furthermore, as described above, relay station MS1 continues mapping relay data to available subcarriers, and does not change the frequencies of transmission subcarriers for relay station MS1. That is, even if relay

10   station MS1 has a function of relaying data, relay station MS1 transmits data of relay station MS1 as a first priority. Therefore, it can be seen that relay station MS1 is influenced little by relaying data.

[0030]   FIG.6 illustrates a case in which mobile station

15   (relay station) MS1 within the cell relays downlink communication between mobile station (relay requesting station) MS2 outside the area and base station BS1, that is, a case of downlink relay.

[0031]   In downlink, cases in which mobile station MS1

20   performs relay are limited as follows. That is, at the timing when mobile station MS1 transmits data to base station BS1, mobile station MS1 relays transmission data for mobile station MS2 from base station BS1. To be more specific, mobile station MS1 transmits transmission data

25   S6 transmitted from base station BS1 to mobile station MS2 at the same timing as the timing for transmission data S5 of mobile station MS1.

[0032]   FIGs.7A to 7C illustrate a timing when mobile station MS1 relays data of base station BS1.

[0033]    FIG.7A shows uplink communication/downlink communication timings in a TDD system.  Furthermore, FIG.7B shows a transmission signal of base station BS1 (received signal at relay station MS1), and FIG.7C shows a transmission signal at relay station MS1.

[0034]   As shown in FIG.7B, at timing t11, base station BS1 transmits data S6 for mobile station MS2 to mobile station MS1.  Mobile station MS1 receives this data S6 and temporarily stores data S6 in a buffer.  Then, as shown in FIG.7C, after waiting until the timing for transmitting data S5 of mobile station MS1 to base station BS1--that is, uplink communication timing t14--and at this timing t14, mobile station MS1 multiplexes relay data S6 stored in the buffer with data S5 of mobile station MS1 and transmits the multiplexed data.

[0035]   Relay data S6 is downlink relay data though transmitted  at  uplink  communication  timing  t14. Therefore, mobile station MS2 receiving this relay data S6 needs to perform reception processing at an uplink communication timing.

[0036]   Furthermore, at this time, as described in uplink communication, mobile station MS1 determines whether or not there is an available subcarrier in OFDM frequencies.

[0037]    FIG.8 shows an example of a usage state of transmission subcarriers for relay station MS1.

[0038]    In this example, subcarriers for center frequencies f13 to f16 are available subcarriers (subcarriers for base station BS1).  Then, mobile station MS1 maps data for mobile station MS2 from base station BS1 to the available subcarriers, and multiplexes the subcarriers with subcarriers to which data for base station BS1 from mobile station MS1 is mapped and transmits the subcarriers.

[0039]    FIG.9 is a block diagram showing a main configuration of mobile station MS1 (mobile station apparatus 100) according to this embodiment implementing the above-described operations.

[0040]  Sections of this mobile station apparatus 100 implement the following operations:

[0041]  Antenna 101 receives a radio signal from another station (base station BS1 or another mobile station such as mobile station MS2), and transmits a radio signal from mobile station MS1.  TDD switch 102 switches between transmission and reception of the radio signal in synchronization with uplink/downlink timings in the TDD system.  Reception RF section 103 performs predetermined radio reception processing such as down-conversion on the radio signal received via antenna 101, and obtains a baseband signal.  OFDM reception section 104 performs predetermined OFDM reception processing such as inverse fast Fourier transform (IFFT) on the baseband signal, and obtains subcarrier signals from the multicarrier

baseband signal.

[0042]    Frequency separation section 105 separates subcarrier signals by frequency (refer to FIG.3 and FIG.8), and separates data for mobile station MS1 from data for another station.        Subject-station data channel demodulation section 106 demodulates data for mobile station MS1 and obtains received data for mobile station MS1.   Other-station data channel demodulation section 107 demodulates data for another station and temporarily stores this demodulated data in buffer 108.

[0043]    On the other hand, when transmission data is generated, buffer 111 temporarily stores the data.

[0044]    Transmission timing determination section 112 determines a timing for transmitting data of mobile station MS1 in accordance with the uplink/downlink timing in the TDD system, reads the stored transmission data from buffer 111 according to this timing, and outputs the transmission data to transmission frequency determination section 113.  Furthermore, transmission timing determination section 112 reports the transmission timing of mobile station MS1 to buffer 108.

[0045]    Transmission frequency determination section 113 determines frequencies (subcarriers) needed to transmit this data based on the transmission data size or the like outputted from transmission timing determination section 112, and determines subcarriers needed to transmit a control channel.  Furthermore, when there are available

subcarriers as already described using FIG.3 and FIG.8, transmission frequency determination section 113 reports the presence of available subcarriers and information about these available subcarriers to other-station data

5  channel   modulation   section   114.    Furthermore, transmission frequency determination section 113 reports information about the subcarriers use by mobile station MS1 and  available  subcarriers,  to  control  channel generation section 115.

10  [0046]  Buffer 108 outputs the stored data for another station to other-station data channel modulation section 114 based on the transmission timing of mobile station MS1 reported from transmission timing determination section 112.

15  [0047]  When the presence of available subcarriers is reported  from  transmission  frequency  determination section 113,  other-station  data  channel  modulation section 114 performs predetermined modulation processing such as QPSK on data for another station outputted from

20  buffer 108 and outputs the result to frequency multiplex section 118.

[0048]  Control channel generation section 115 generates a control channel signal reporting the information about the subcarriers used by mobile station MS1 and available

25  subcarriers  reported  from  transmission  frequency determination  section  113,  and  outputs  the  control channel signal to control channel modulation section 116.

[0049]  Control channel modulation section 116 performs predetermined modulation processing such as QPSK on the control channel signal and outputs the result to frequency multiplex section 118.   BS data channel modulation section 117 performs predetermined modulation processing such as QPSK on data for base station BS1 from mobile station MS1 and outputs the result to frequency multiplex section 118.

[0050]  Frequency multiplex section 118 maps modulation signals outputted from other-station data channel modulation section 114, control channel modulation section 116 and BS data channel modulation section 117 to subcarriers determined by frequency determination section 113, and thereby obtains the transmission signal multiplexed on the frequency axis, and outputs the transmission signal to OFDM transmission section 119.

[0051]  OFDM transmission section 119 performs predetermined OFDM transmission processing such as fast Fourier transform (FFT) on the transmission signal and obtains a multicarrier baseband signal.   Transmission RF section 120 performs predetermined radio transmission processing such as up-conversion on this baseband signal and transmits the obtained radio signal via TDD switch 102 and antenna 101.

[0052]  In addition, mobile station MS1 includes an identifier of mobile station MS1 in relay data so that base station BS1 can recognize the data relay from another

mobile station.

[0053]    FIG.10 is a block diagram showing a main configuration of base station BS1 (base station apparatus 150) according to this embodiment.

[0054]    Sections of this base station apparatus 150 implement the following operations:

[0055]    Modulation section 151 performs predetermined modulation processing such as QPSK on transmission data. Transmission timing determination section 152 determines a transmission timing for mobile station MS1 in accordance with the uplink/downlink timing in the TDD system and reports this timing to buffer 153.  Buffer 153 temporarily stores the modulation signal outputted from modulation section 151 and outputs the stored modulation signal to OFDM transmission section 154 based on the transmission timing of mobile station MS1 reported from transmission timing determination section 152.  OFDM transmission section 154 performs predetermined OFDM transmission processing such as fast Fourier transform on the modulation signal and obtains a multicarrier baseband signal.    Transmission RF section 155 performs predetermined radio transmission processing such as up-conversion on the baseband signal and transmits the obtained radio signal via TDD switch 156 and antenna 157.

[0056]    On the other hand, reception RF section 158 performs predetermined radio reception processing such as down-conversion on the radio signal received via

antenna 157 and TDD switch 156 and obtains a baseband signal. OFDM reception section 159 performs predetermined OFDM reception processing such as inverse fast Fourier transform on the baseband signal and obtains

5    subcarrier signals from the multicarrier baseband signal. Control channel demodulation section 160 performs demodulation processing on the control channel transmitted from mobile station MS1, extracts information about the subcarriers used by mobile station MS1

10   (subcarriers for mobile station MS1) and available subcarriers, and outputs the information to frequency separation section 161. Frequency separation section 161 separates subcarrier signals by frequency based on the information about the subcarriers used by mobile

15   station MS1 and the available subcarriers, and separates signals from mobile station MS1 from signals from mobile station MS2. Data channel demodulation sections 162-1 and 162-2 perform demodulation processing on the signals from mobile station MS1 and the signals from mobile station

20   MS2, and obtains data from mobile station MS1 and data from mobile station MS2.

[0057]  In this way, according to this embodiment, in the multihop system, relay station MS1 receives data that is requested to be relayed by another station (mobile

25   station MS2 outside the area or base station BS1), and temporarily stores the data in the buffer. Then, after waiting until the timing for transmitting data of mobile

station MS1, and, when this timing arrives, relay station MS1 frequency division multiplexes the stored relay data with the data of mobile station MS1, and transmits the frequency division multiplexed data to the relay

5   destination station (base station BS1 or mobile station MS2). By this means, it is possible to relay communication of another station and suppress increase in power consumption of mobile station MS1.

[0058] Furthermore, in the above configuration, relay

10  station MS1 judges whether or not there is a subcarrier that is not used by mobile station MS1 (available subcarrier) in OFDM frequencies, and maps relay data to this available subcarrier. By this means, without sacrificing data transmission of mobile station MS1, data

15  relay of another station can be implemented.

[0059] In addition, when data relay is carried out, relay station MS1 may report the relay to mobile station MS2 outside the area. By this means, the following effects can be recognized.

20  [0060] Generally, since the mobile station constantly monitors the reception level of pilot signals transmitted from the base station, a user of the mobile station can judge whether or not the user is located within a cell. Therefore, though the user of mobile station MS2 according

25  to this embodiment recognizes that the user is located outside the cell, the user tries to transmit data to base station BS1. In this situation, the user of mobile

station MS2 may want to confirm whether or not data transmission is possible (or was possible). As a method for telling this user whether or not data transmission is possible, it is considered that mobile station MS2

5  searches for a relay station before data transmission, holds the relay station, and transmits data to this relay station. In this case, mobile station MS2 performs communication after holding the relay station, thereby naturally judging that data transmission is possible.

10  However, in this method, processing of searching for a relay station and holding this relay station requires signaling (exchanging control signals) with this relay station, and since this signaling is different from usual communication processing in the case in which the mobile

15  station is located within the cell, a new signaling circuit is required. On the other hand, as described above, if relay station MS1 reports the data relay to mobile station MS2 when data relay is carried out, mobile station MS2 can judge that data transmission is possible with a simple

20  configuration without signaling in advance. Then, by displaying the success of data transmission on a display or the like, this fact can be reported to the user of mobile station MS1. Furthermore, since relay station MS1 can report to mobile station MS2 outside the area

25  simultaneously upon data transmission to base station BS1, transmission power does not increase markedly. Further, a signal transmitted by relay station MS1 to

base station BS1 can be received by mobile station MS2, except for a case in which directivity is added and transmitted. Therefore, if this signal is used as the above-described report signal, relay station MS1 does

5    not need to separately transmit a report signal to mobile station MS2.

[0061]   Furthermore, in this embodiment, although a case has been described as an example in which relay station MS1 directly communicates with base station BS1, this

10   is by no means limiting, and communication may be performed via another relay station between mobile station MS1 and base station BS1.

[0062]   Furthermore, in this embodiment, although a case has been described as an example in which a relay station

15   is one of mobile station MS1--that is, there is one communication route (relay route) of relay data--, there may be a plurality of relay routes. For example, two mobile stations--mobile station MS1 and mobile station MS1'--may relay data of mobile station MS2 outside the

20   area. Then, if timings for transmitting relay data of two relay stations (uplink timings in the TDD system) are the same, from the viewpoint of base station BS1, data of mobile station MS2 outside the area seems to arrive through two communication paths, and the situation is

25   practically equivalent to the situation of communication under the multipath environment. Furthermore, if transmission timings of two relay stations are different,

from the viewpoint of base station BS1, the situation is practically equivalent to the situation in which mobile station MS2 retransmits data.

[0063] Furthermore, here, although a case has been described as an example in which data from mobile station MS2 located outside the cellular system is relayed, this is by no means limiting, and data from a mobile station that cannot receive a signal from base station BS1 located within the cell (mobile station located in a dead area), may be relayed. That is, the present invention is effective for measures against the dead area.

[0064] Furthermore, in an example of FIG.3 and FIG.8, although a case has been described as an example in which available subcarriers of the relay station are successive on the frequency axis, available subcarriers may be distributed unsuccessively and discretely.

[0065] Furthermore, in this embodiment, although a case has been described as an example in which, when the capacity of available subcarriers is insufficient for a data relay, mobile station MS1 does not perform a relay, mobile station MS1 may relay only part of data. Specifically, mobile station MS2 located outside the area assigns priorities in advance to data to be transmitted to base station BS1 based on data accuracy or the like. Then, mobile station MS2 transmits this data with priorities to relay station MS1. Relay station MS1 maps data in the order of descending priorities out of the received data to

available subcarriers of relay station MS1, and at the

stage at which mapping of all relay data is completed

or available subcarriers are all filled, multiplexes the

data with the data of relay station MS1 and transmits

5  the multiplexed data to base station BS1. By this means,

even when the size of the relay data is larger than the

capacity of available subcarriers, data is selected in

the order of descending priorities and relayed to base

station BS1. Therefore, at base station BS1, although

10  data accuracy is poor, a state can be maintained that

is meaningful for communication (communication can be

practically established.)

[0066]   (Embodiment 2)

In Embodiment 1, a case has been described as an

15  example in which the present invention is applied to an

OFDM-TDD system, but in Embodiment 2, a case will be

described in which the present invention is applied to

an OFDM-FDD (Orthogonal Frequency Division Multiplex -

Frequency Division Duplex) system. In the TDD system

20  described in Embodiment 1, since the same frequency band

is used in uplink relay and downlink relay, the relay

station does not need to switch the frequencies to be

used according to uplink or downlink. However, in the

FDD system described in this embodiment, as the frequency

25  band to be used is different between uplink and downlink,

the configuration of the relay station substantially

differs from Embodiment 1. The configuration of the relay

station will be described later in detail.

[0067]    FIG.11A and FIG.11B illustrate a flow of a case
in which relay station MS1 relays data of relay requesting
station MS2.    In addition, the assumed situation is the
5    same as in FIG.1, and mobile station MS1 within the cell
relays uplink communication between mobile station MS2
located outside cell A1 and base station BS1.    Signals
are assigned the same reference numerals as in FIG.1.

[0068]    Relay station MS1 receives transmission signal
10    S2 in the uplink frequency from relay requesting station
MS2 at an arbitrary timing.    Then, relay station MS1
temporarily stores the received signal in a buffer, and,
at the timing of data transmission to base station BS1
of relay station MS1, by mapping data S2 from relay
15    requesting    station    MS2    to    available    subcarrier,
multiplexes data S1 of relay station MS1 with relay data
S2 and transmits the multiplexed data.    The timing at
which relay station MS1 transmits relay data S2 to base
station BS1 is irregular, and the time interval from relay
20    station MS1 receiving relay data S2 to transmitting this
data to base station BS1 is also irregular.    Therefore,
when a predetermined time passes while waiting for
transmission of relay data S2, relay station MS1 cancels
relay and discards relay data S2.

25    [0069]    FIG.12 is a view showing an example of a usage
state of transmission subcarriers for relay station MS1.

[0070]    Subcarriers of center frequencies f13 to f16 are

used in transmission from relay station MS1 to base station

BS1--that is, transmission of the data of relay station

MS1--and the subcarriers of center frequencies f1 to f12

are available subcarriers.  Then, relay station MS1 maps

5   signal S2 received from relay requesting station MS2 to

available subcarriers (center frequencies f1 to f12),

and performs relay transmission to base station BS1.

[0071]  In addition, relay data may be mapped to any

subcarrier if a subcarrier is an available subcarrier,

10  and, for example, when a successive plurality of

subcarriers can be held as available subcarriers, relay

data is mapped to these subcarriers.  Furthermore, when

available subcarriers are located separately one

another--that is, located discretely--relay data is

15  mapped discretely.

[0072]  In addition, in FIG.11 and FIG.12, a case of uplink

relay has been described as an example, but the present

invention can be implemented by the same relay method

in the case of downlink relay.  Since this has been

20  described in Embodiment 1, the explanation is omitted

here.

[0073]  FIG.13 is a block diagram showing a main

configuration of mobile station apparatus 200 according

to this embodiment implementing the above-described

25  operations.  In addition, since mobile station apparatus

200 has the same configuration as mobile station apparatus

100 (refer to FIG.9) described in Embodiment 1, components

basically performing the same operation are assigned the same reference numerals without further explanations. Furthermore, a plurality of components with the same configuration are indicated with branch numerals assigned

5    after reference numerals.

[0074]   One of the features of mobile station apparatus 200 is to have a function of receiving relay data for another station (for example, uplink frequency reception RF section 202, OFDM reception section 104-2 and frequency

10   separation section 105-2) in addition to a normal reception function.

[0075]   Function of each section of mobile station apparatus 200 will be described below.

[0076]   Downlink frequency reception RF section 201

15   performs predetermined radio reception processing such as down-conversion on a downlink radio signal from base station BS1 received via antenna 101, that is, a radio signal of downlink frequency, and obtains a baseband signal.  Data included in the radio signal of downlink

20   frequency is normal communication data for mobile station MS2, or relay data for another station.

[0077]   Uplink frequency reception RF section 202 performs predetermined radio reception processing such as down-conversion on a signal such as relay data from

25   another station (for example, MS2) received via antenna 101--that is, a radio signal of uplink frequency--and obtains a baseband signal.  Data included in the radio

signal of uplink frequency is, as shown in FIG.11 and FIG.12, relay data of uplink relay for base station BS1 from another station. There is also a case in which, as described below, mobile station MS2 is a relay requesting

5   station located outside the cell, and data is relay data of downlink relay transmitted from a relay station for mobile station MS2. Downlink relay will be described later in detail.

[0078] There are two OFDM reception sections 104 for

10  downlink frequency and for uplink frequency (104-1 and 104-2). Furthermore, there are two frequency separation sections 105 for downlink frequency and for uplink frequency (105-1 and 105-2).

[0079]   Subject-station data channel demodulation

15  section 106 demodulates data for mobile station MS2 outputted from OFDM reception section 104-1 or OFDM reception section 104-2, and obtains data for mobile station MS2. Other-station data channel demodulation section 107 demodulates data for another station

20  outputted from OFDM reception section 104-1 or OFDM reception section 104-2, and temporarily stores this demodulated data in buffer 108.

[0080] On the other hand, uplink frequency transmission RF section 211 performs predetermined radio transmission

25  processing such as up-conversion on the baseband signal outputted from OFDM transmission section 119 and transmits the obtained radio signal of uplink frequency

via antenna 101. Data included in the radio signal of uplink frequency is normal communication data to base station BS1 of mobile station MS2, or, as described below, relay data of uplink relay and downlink relay.

5  [0081] FIG.14 is a view summarizing the usage methods of each frequency band in the communication system according to this embodiment.

[0082] A case of uplink relay already described in FIG.11 and FIG.12 will be described.

10  [0083] In the case of uplink relay, transmission from relay requesting station MS2 to relay station MS1 (signal S2) is performed using uplink as in normal communication. Furthermore, transmission from relay station MS1 to base station BS1 (signal S2) is performed using uplink as in

15  normal communication. Therefore, frequency to be used is uplink frequency in either route.

[0084] Next, a case of downlink relay will be described.

[0085] In the case of downlink relay, transmission from base station BS1 to relay station MS1 (signal S6) is

20  performed using downlink (downlink frequency) as in normal communication. However, transmission from relay station MS1 to relay requesting station MS2 (signal S6) is performed using uplink frequency, which is different from normal communication.

25  [0086] As already described, in the FDD system, since the frequency band to be used is different between uplink and downlink, the normal (conventional) mobile station

apparatus cannot receive transmission data of another mobile station apparatus. However, as shown in FIG.13, since mobile station apparatus 200 according to this embodiment has a reception system for uplink frequency

5    (uplink frequency reception RF section 202 to frequency separation section 105-2), mobile station apparatus 200 can receive transmission data from another mobile station apparatus. That is, if relay station MS1 and relay requesting station MS2 both have the configuration of

10   mobile station apparatus 200, relay requesting station MS2 can receive relay data transmitted from relay station MS1 using uplink frequency by the reception system for uplink frequency. Therefore, as shown in FIG.14, downlink relay between mobile station apparatuses is

15   performed using uplink frequency.

[0087]   In addition, the relay station embeds an identifier in the transmission signal so that the transmission data can be identified as the data addressed to base station BS1 or the relay requesting station.

20   [0088]   In this way, according to this embodiment, in the multihop system, relay station MS1 receives data that is requested to be relayed by another station (mobile station MS2 outside the area or base station BS1), and temporarily stores the data in a buffer. Then, after

25   waiting until the timing for transmitting the data of mobile station MS2, and, when this timing arrives, relay station MS1 frequency division multiplexes the stored

relay data with the data of mobile station MS1 and transmits the frequency division multiplexed data to a relay destination station (base station BS1 or mobile station MS2). By this means, it is possible to implement

5    communication relay of another station and suppress increase in power consumption of mobile station MS1. That is, since the relay station relays a signal of the relay requesting station only in the case in which there is a transmission signal of the relay station, it is

10   possible to suppress power consumption.

[0089] In addition, in this embodiment, a case has been described as an example in which downlink relay between mobile stations (between the relay station and the relay requesting station) is performed using uplink frequency.

15   However, downlink relay may be performed using downlink frequency as in normal downlink communication. In this case, the configuration of mobile station apparatus 200a is as shown in FIG.15. OFDM transmission section 119-2 and downlink frequency transmission RF section 212 are

20   transmission systems performing downlink relay from the relay station to the relay requesting station. In this case, since there is no data for the mobile station in the radio signal of uplink frequency, frequency separation section 105-2 separates (extracts) only relay

25   data for another station and outputs the data to other-station data channel demodulation section 107.

[0090] Furthermore, when relay station MS1 carries out

data relay, relay station MS1 may report the data relay to mobile station MS2 outside the area.

[0091] Furthermore, in this embodiment, a case has been described as an example in which relay station MS1 directly communicates with base station BS1, but this is by no means limiting, and relay station MS1 may communicate via another relay station between mobile station MS1 and base station BS1.

[0092] Further, in this embodiment, a case has been described as an example in which there is one relay route, but there may be a plurality of relay routes.

[0093] Still further, in this embodiment, a case has been described as an example in which data from mobile station MS2 located outside the cellular system is relayed, but data from a mobile station located in a dead area may be relayed.

[0094] The embodiments of the present invention have been described.

[0095] The mobile station apparatus and communication relay method according to the present invention are not limited to the above-described embodiments and can be implemented by making various changes. For example, the embodiments can be appropriately combined and implemented.

[0096] In addition, in the above-described embodiments, although cases have been described as an example in which a mobile station apparatus such as a mobile telephone

is used as a relay station or a relay requesting station, other communication terminals, for example, a PDA (Personal Digital Assistant) or a laptop computer can be used.

5   [0097]   Furthermore, although a case has been described as an example in which the present invention is implemented with hardware, the present invention can be implemented with software.   For example, by describing the communication relay method algorithm according to the

10   present invention in a programming language, storing this program in a memory and making an information processing section execute this program, it is possible to implement the same function as the mobile station apparatus and communication terminal apparatus of the present

15   invention.

[0098]   Furthermore, each function block used to explain the above-described embodiments is typically implemented as an LSI constituted by an integrated circuit.   These may be individual chips or may partially or totally

20   contained on a single chip.

[0099]   Furthermore, here, each function block is described as an LSI, but this may also be referred to as "IC", "system LSI", "super LSI", "ultra LSI" depending on differing extents of integration.

25   [0100]   Further, the method of circuit integration is not limited to LSI's, and implementation using dedicated circuitry or general purpose processors is also possible.

After LSI manufacture, utilization of a programmable FPGA (Field Programmable Gate Array) or a reconfigurable processor in which connections and settings of circuit cells within an LSI can be reconfigured is also possible.

5   [0101] Further, if integrated circuit technology comes out to replace LSI's as a result of the development of semiconductor technology or a derivative other technology, it is naturally also possible to carry out function block integration using this technology. Application in

10   biotechnology is also possible.

[0102] The present application is based on Japanese Patent Application No.2004-068793, filed on March 11, 2004, and Japanese Patent Application No.2005-56381, filed on March 1, 2005, the entire content of which is

15   expressly incorporated by reference herein.


Industrial Applicability

[0103] The communication terminal apparatus and communication relay method according to the present

20   invention have the effect of implementing communication relay of another station and suppressing increase in power consumption of the communication terminal apparatus, and can be applied to a multihop system and the like.